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Visitation Aspect and Roles of Nakdong River Estuary as Resting Ground for *Limosa* spp.

Soon-Bok Hong[1]* and In-Sup Lee[2]
[1]*Basic Science Research Center, Kyungsung University, Busan 608-736, Korea*
[2]*Department of Biology Kyungsung University, Busan 608-736, Korea*

Abstract: This study was conducted to know the visitation aspect of *Limosa* spp. and the roles of Nakdong River estuary as resting ground for *Limosa* spp. This study was conducted during the two periods for the early 1990s (May, 1989 to April 1993) and the mid-2000s (May, 2002 to April 2008) in order to assess the state of long-term monitoring of *Limosa* spp. in Nakdong River estuary, an area characterized by rapidly changing environment. Among the 9 genus, 27 species and 116,761 individuals observed during the study (May, 1989 to April 1993, May, 2002 to April 2008, total of 10 years), 1,071 individuals of the black-tailed godwit (*Limosa limosa*) and 3,214 individuals of the bar-tailed godwit (*Limosa lapponica*) of genus *Limosa* of family Scolopacidae were observed. 2 species observed was 4,285 individuals and which was 3.67% of total individuals observed. Among the case of the 2 species and 4,285 individuals of genus *Limosa*, 834 individuals of the black-tailed godwit and 2,216 individuals of the bar-tailed godwit, for a total of 3,050 individuals, were observed during the early 1990s (between years 1989 and 1993), and 237 individuals of the black-tailed godwit and 998 individuals of the bar-tailed godwit, for a total of 1,235 individuals, were observed during the mid 2000s. Comparison of the visitation aspects of the two periods did not show significant difference between the early 1990s and the mid-2000s ($P<0.14$), and the individuals observed in the early 1990s (Mean=762.50) were greater than those observed in the mid-2000s (Mean=205.83). The average number of individuals of the 5 regions was 41.17 individuals, with the average number of individuals being 136.83 individuals in Daemadeung (DMD), 14.33 individuals in Jangja · Shinjado (JJ.SJD), 30.00 individuals in Saja · Doyodeung (SJ.DY), 17.83 individuals in southern Eulsukdo (LUD) and 6.83 individuals in Eulsukdo (USD). Statistical analysis showed significant difference among the 5 sites ($P<0.05$). A total of 1,235 individuals were observed during 6 years, including 821 individuals in Daemadeung, 180 individuals in Saja · Doyodeung, 107 individuals in southern Eulsukdo, 86 individuals in Shinjado and 41 individuals in Eulsukdo.

Keywords: *Limosa* spp., Black-tailed Godwit, Bar-tailed Godwit, Visitation aspect

Introduction

Nakdong River estuary is located at the southern tip of the Korean peninsula and a wide range of migratory birds visit the area. The region is an important place for shorebirds as stopping and breeding ground in autumn and wintering period. A total of 27 species of family Scolopacidae were observed in the downstream region of Nakdonggang (River), including 9 species of genus *Calidris*, 1 species of genus *Arenaria*, 1 species of genus *Limicola*, 7 species of genus *Tringa*, 1 species of genus *Xenus*, 1 species of genus *Heteroscelus*, 1 species of genus *Actitis*, 2 species of genus *Limosa*, 3 species of genus *Numenius*, and 1 species of genus *Gallinago*. Genus *Limosa* includes mid-sized birds, such as the black-tailed godwit (*Limosa limosa*) and the bar-tailed godwit (*Limosa lapponica*).

Based on its importance as a visiting ground of such migratory bird species, the Nakdong River estuary was designated as the 179th natural monument by the Cultural Heritage Administration (July 13th, 1966: 247,933,884), and the Nakdong River Estuary plays an important role as a wintering ground for winter migratory birds and visiting grounds for birds in east Asia (Post, 1983; Hong, 1997). Furthermore, since the Nakdong River estuary region includes mud flats, wetlands, abundant aquatic resources and visiting grounds for migratory birds, 5 sections of the area have been selected for government protection.

Past studies on genus *Limosa* have included primarily studies on the bar-tailed godwit, such as the study on the use of wintering habitat of female and male bar-tailed godwit (Zharikov *et al*., 2002) and their migration (Gill *et al*., 2005; Landys *et al*., 2000; Wilson *et al*., 2007). Studies on the family Scolopacidae of Nakdong River estuary has been limited to only the study on the shorebirds of the region (Hong, 2005), and no studies have been conducted on genus *Limosa*.

*To whom correspondence should be addressed.
Tel: +82-11-832-6043
E-mail: birdhsb@hanmail.net

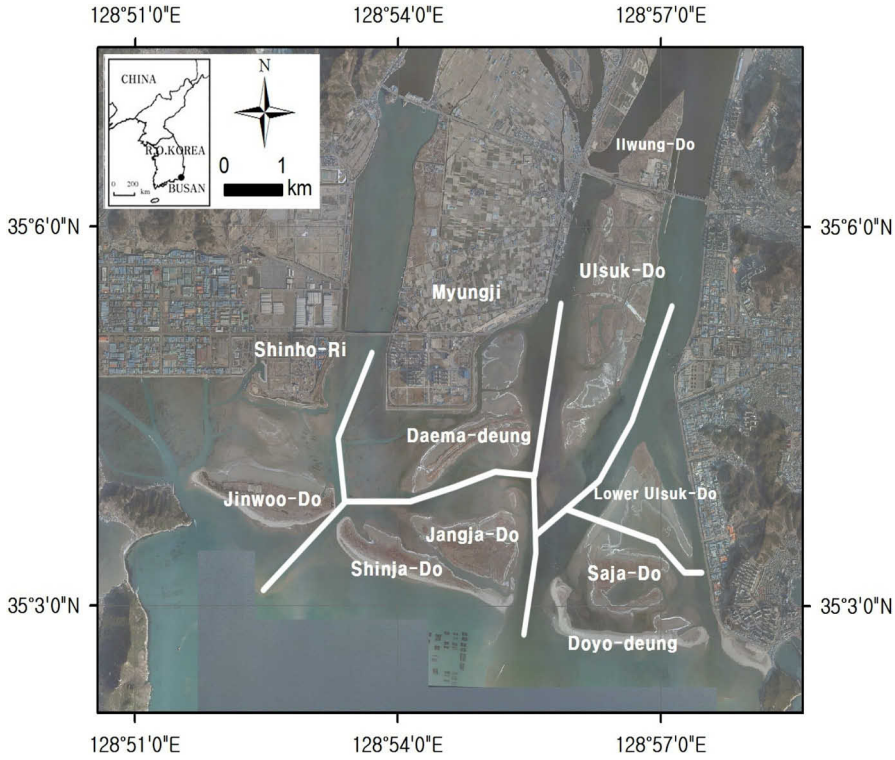

Fig. 1. Study area on Nakdong Estuary. The survey period between May 1989 and April 1993, and from May 2002 to April 2008.

The results of the long-term monitoring of family Scolopacidae which use Nakdong River estuary as resting place, alongside analysis of their visiting aspect and habitat preference, are predicted to become very important data for the preservation of a healthy ecosystem and habitat of migratory birds of this region.

Therefore, this study was conducted to compare and analyse the documents recorded in the early 1990s and the mid-2000s in order to assess the visiting aspect and habitat preference of genus *Limosa* of family Scolopacidae.

Study Methods

The survey for this study was conducted 1 to 3 times per month during the early 1990s (May, 1989 to April 1993) and 1 to 2 times per month during mid-2000s (May, 2002 to April 2008) in order to record number of individuals (the highest number of individuals was selected for each month).

5 study sites were selected for this study: ①Daemadeung, ② Jangja · Shinjado, ③ Saja · Doyodeung, ④ southern Eulsukdo, ⑤ Eulsukdo (Fig. 1).

The strip transect method, which incorporates moving along a trail on a vessel to make observation using the naked eye or binoculars (35×8, Nikon). and the point census method, which incorporates observation using a telescope (×20-60, Sony) without a vessel, were used during the study (Fig. 1).

The individuals of shorebirds observed using the naked eyes, binoculars or telescopes were identified and recorded. The Mann-Whitney U test was used for monthly comparative analysis of the two groups, and the one-way ANOVA analysis was used for regional comparative analysis to the number of individuals.

Results

Overview

A total of 9 genus, 27 species and 116,761 individuals of family Scolopacidae were observed and recorded in the downstream region of Nakdonggang (River), including 9 species of genus *Calidris*, 1 species of genus *Arenaria*, 1 species of genus *Limicola*, 7 species of genus *Tringa*, 1 species of genus *Xenus*, 1 species of genus *Heteroscelus*, 1 species of genus *Actitis*, 2 species of genus *Limosa*, 3 species of genus *Numenius*, and 1 species of genus *Gallinago*. And 2 species and 4,285 individuals of genus *Limosa* of family Scolopacidae were observed.

The number of individuals of genus *Limosa*

Among the 9 genus, 27 species and 116,761 individuals observed during the study (10 years), 1,071 individuals of the black-tailed godwit and 3,214 individuals of the bar-tailed godwit of genus *Limosa* of family Scolopacidae were observed, which was 3.67% of total numbers observed.

Among the number of individuals of genus *Limosa*

Table 1. Comparison of early 1990s to middle 2000s in the number of individuals of Plover (*Pluvialis* spp.) in the Nakdong estuary (89-93: 1989-1993, 02-08: 2002-2008)

Division	Year	Mean	SD	M-W's U	p
89-93	4	762.50	829.16	26.00	0.136
02-08	6	205.83	160.13		
Total	10	428.50	571.01		

[1)]SD=Standard Deviation, [2)]M-W's U=Mann Whitney U test

observed during the early 1990s (between May, 1989 and April, 1993), 2 species and 1,994 individuals in the 1st year (May, 1989-April, 1990), 2 species and 439 individuals in the 2nd year (May, 1990-April, 1991), 2 species and 188 individuals in the 3rd year (May, 1991-April, 1992), and 1 species and 429 individuals were observed in the 4th year (May, 1992-April, 1993). And the numbers observed during the mid-2000s (May, 2002-April, 2002) were 2 species and 123 individuals in the 5th year (May, 2002-April, 2003), 2 species and 458 individuals in the 6th year (May, 2003-April, 2004), 2 species and 328 individuals in the 7th year (May, 2004-April, 2005), 2 species and 207 individuals in the 8th year (May, 2005-April, 2006), 1 species and 61 individuals in the 9th year (May, 2006-April, 2007), and 2 species and 58 individuals in the 10th year (May, 2007-April, 2008).

Monthly comparison of genus *Limosa* visited during the two study periods

The average numbers recorded during the two study periods were analysed to assess the degree of change in the number of individuals of genus *Limosa* (Table 1). As shown in Table 1, there was no significant difference in the number of individuals between the early 1990s and mid-2000s ($P<0.14$), but the number of individuals was greater in the early 1990s (Mean=762.50) than in the mid-2000s (Mean=205.83).

The average numbers recorded during the two study periods were also analysed to assess the degree of change by month in the number of individuals of genus *Limosa* (Table 2). As shown in Table 2, the average annual number of individuals between the early 1990s and mid-2000s showed significant difference in March and July ($P<0.05$), but the numbers did not show significant difference in other month.

Based on the results of the study on the average number of individuals observed during the early 1990s and the mid-2000s, in the case of the early 1990s, birds did not arrive or arrived in small number between October and March, but a high number began to arrive in April. The highest number of individuals arrived during July, and the number began to decrease in August and September. In the case of mid-2000s, most of all individuals arrived in April and May in spring, and they began to arrive in August in fall season and

Table 2. Montly Comparison of the number of Plover (*Pluvialis* spp.) in the Nakdong estuary (89-93: 1989-1993, 02-08: 2002-2008)

Month		N (Year)	Mean	SD[1)]	M-W's U[2)]	p
May.	89-93	4	105.00	98.05	5.000	0.134
	02-08	6	37.50	44.82		
Jun.	89-93	4	118.75	224.36	6.000	0.068
	02-08	6	0.00	0.00		
Jul.	89-93	4	201.75	3655.85	3.500	0.041*
	02-08	6	0.33	0.82		
Aug.	89-93	4	86.00	152.04	11.000	0.829
	02-08	6	28.67	20.02		
Sep.	89-93	4	68.25	78.89	8.500	0.454
	02-08	6	23.17	20.29		
Oct.	89-97	4	4.75	7.63	9.000	0.495
	02-08	6	38.33	54.68		
Nov.	89-93	4	0.00	0.00	8.000	0.224
	02-08	6	2.67	6.06		
Dec.	89-93	4	0.00	0.00	12.000	1.000
	02-08	6	0.00	0.00		
Jan.	89-93	4	0.00	0.00	12.000	1.000
	02-08	6	0.00	0.00		
Feb.	89-93	4	5.00	10.00	9.000	0.221
	02-08	6	0.00	0.00		
Mar.	89-93	4	10.00	9.52	3.000	0.018*
	02-08	6	0.00	0.00		
Apr.	89-93	4	163.00	127.21	7.000	0.286
	02-08	6	75.17	63.46		

the highest number of individuals was observed in October. The average number of individuals observed in the early 1990s was approximately 3.7 times larger than that of in the mid-2000s (Fig. 2).

The result of analysis by month to the data obtained in the early 1990s and mid-2000s showed that birds were recorded higher number of individuals from April to September in the early 1990s, and from April to May and from August to October in the mid-2000s.

The comparison of the individuals between the two periods showed that birds were observed continuously from April to September in the early 1990s, while they were observed from April to May, and from August to October in the mid-2000s, displaying seasonal patterns.

Regional aspect of genus *Limosa*

The average number of individuals observed per region during the mid-2000s is shown in Table 3 and Fig 3. As shown in Table 3, the average number of individuals of the 5 regions was 41.17. And the average number of individuals in the each region was 136.83 individuals in Daemadeung (DMD), 14.33 individuals in Jangja · Shinjado (JJ.SJD), 30.00 individuals in Saja · Doyodeung (SJ.DY), 17.83 individuals in southern Eulsukdo (LUD) and 6.83 individuals in Eulsukdo (USD), respectively. The F-value among the regions was 4.270, with p-value of 0.009, and based on significance of $P<0.05$, the results showed significant difference.

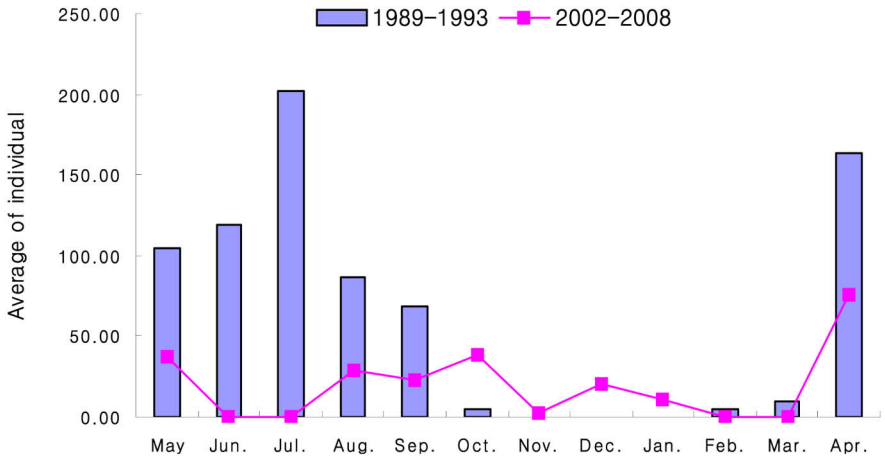

Fig. 2. Monthly change in the average number of individuals in Nakdong estuary in 1989-1993 and 2002-2008.

Table 3. The average of individuals of 5 region in the Nakdong estuary from May 2002 to April 2008 (DMD: Daema-deung, JJ.SJD: Jangja.Sinja-do, SJ.DY: Saja-do.Doyo-deung, LUD: Lower Ulsuk-do, USD: Ulsuk-do)

Site	Year	Mean	SD	F[1)]	P
DMD	6	136.83	135.31		
JJ.SJD	6	14.33	15.97		
SJ.DY	6	30.00	36.57		
LUD	6	17.83	20.48	4.270	0.009*
USD	6	6.83	16.25		
Total	30	41.17	77.29		

*P<0.05, 1) F=F-valus

Table 4. Monthly Trend of *Limosa* Genus at 5 region in the Nakdong estuary from May 2002 to April 2008 (DMD: Daema-deung, JJ.SJD: Jangja.Sinja-do, SJ.DY: Saja-do.Doyo-deung, LUD: Lower Ulsuk-do, USD: Ulsuk-do)

	DMD	JJ.SJD	SJ.DY	LUD	USD
May.	201	24	.	.	.
Jun.	.	.	.	.	.
Jul.	2	.	.	.	.
Aug.	66	10	27	69	.
Sep.	56	35	48	.	.
Oct.	90	.	102	38	.
Nov.	15	.	.	.	1
Dec.	.	.	.	.	.
Jan.	.	.	.	.	.
Feb.	.	.	.	.	.
Mar.	.	.	.	.	.
Apr.	391	17	3	.	40

Monthyl regional aspect of genus *Limosa*

The number of individuals observed monthly for 6 years was a total of 1,235 individuals, with 821 individuals in Daemadeung, 86 individuals in Jangja · Shinja, 180 individuals in Saja · Doyodeung, 107 individuals in southern Eulsukdo and 41 individuals in Eulsukdo. In Daemadeung, where the highest number of individuals was observed, 391 individuals were observed in April and 201 individuals in May. Whereas 102 individuals out of the total of 180 individuals were observed in Saja · Doyodeung in October, and 48 individuals in September (Fig. 4).

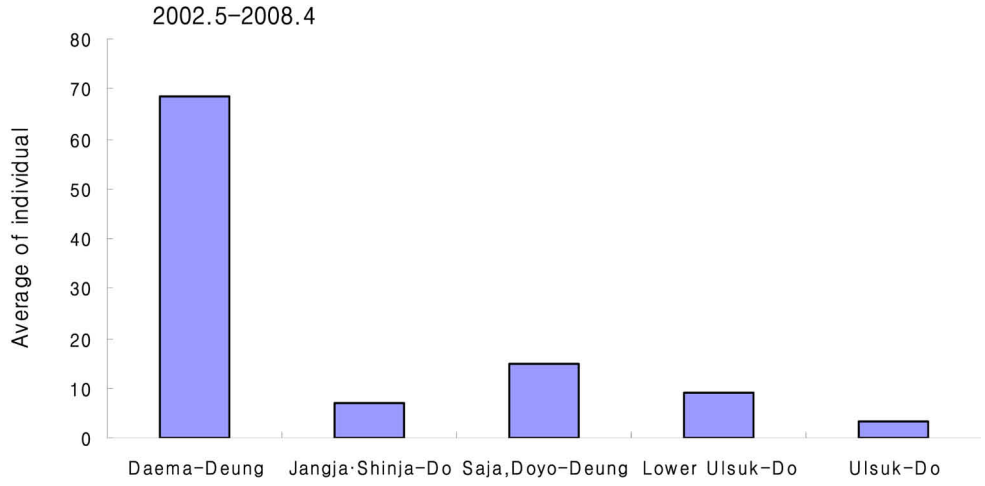

Fig. 3. The average number of individuals of 5 region in the Nakdong estuary between May 2002 and April 2008.

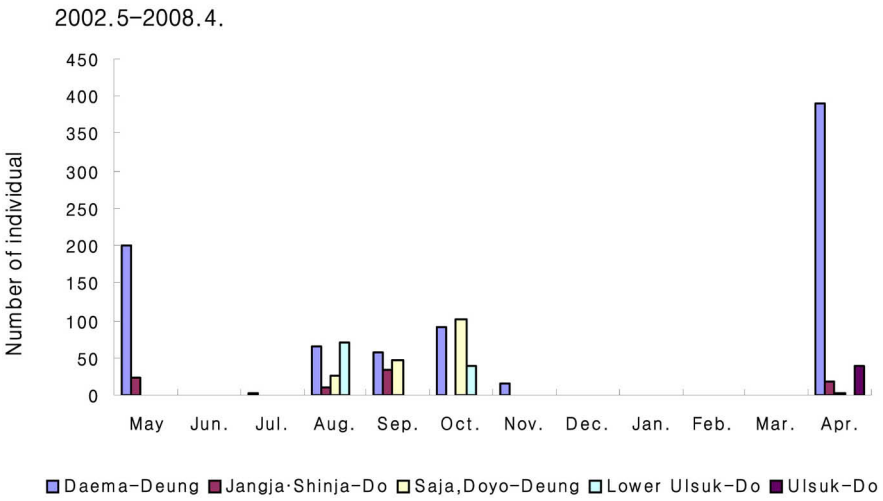

Fig. 4. Monthly variation of the number of individuals at 5 region in the Nakdong estuary between May 2002 and April 2008.

Discussion

Crossing the ocean or regions, it is difficult to people, birds have to travel over hundreds or thousands of km without stopping (Landys *et al*., 2000). Nakdong River estuary provides resting ground for migratory birds through all 4 seasons. And a total of 2 species and 4,285 individuals of genus *Limosa*, including 1,071 individuals of the black-tailed godwit and 3,214 individuals of bar-tailed godwit were observed in this region.

Among the 2 species and 4,285 individuals of *Limosa* genus, a total of 3,050 individuals were observed during the early 1990s, including 834 individuals of the black-tailed godwit and 2,216 individuals of the bar-tailed godwit. And a total of 1,235 individuals were observed during the mid-2000s, including 237 individuals of the black-tailed godwit and 998 individuals of the bar-tailed godwit. These results show that higher numbers of the black-tailed godwit and the bar-tailed godwit were observed in the mid-2000s than in the early 1990s.

The black-tailed godwit is found in the east Siberia and Mongolia and is observed wintering along the region between the Bay of Bengal, Taiwan, the Philippines, and southern Australia (Cramp and Simmons, 1983). In the case of the early 1990s, 67 individuals were observed in May, 135 individuals in June, 235 individuals in July, 295 individuals in August and 77 individuals in September, and 21 individuals in April. A total of 830 individuals, which was 77.50% of the 1,071 individuals observed for the 10 years of the study. While this species was observed between May and September, known as their breeding season, but there is no evidence of actions of their breeding confirmed yet.

With the start of the mid-2000s, the black-tailed godwit was observed continuously in small numbers only. They displayed significant increase in northwestern Europe during the 20th century, and factors such as farming developments, including drainage construction and rotary-based tilling, affect changes in their numbers (Cramp and Simmons, 1983). Such factors are predicted to reduce the number of individuals of black-tailed godwit.

The bar-tailed godwit travels an exceptionally long distance and inhabits sea coasts. They breed in Scandinavia, Russia and northwestern part of Alaska during non-breeding seasons (Gill *et al*., 2005; Wilson *et al*., 2007). It is hypothesized that, during the northward migration, the bar-tailed godwit makes a non-stop 5000 to 8000 trip from New Zealand or eastern Australia to Japan or the northern coast of the Yellow Sea (Riegen, 1999; Battley and Piersma, 2005). The northern coast of the Yellow Sea is an important final destination for the bar-tailed godwit (Wilson and Barter, 1998). Individuals which will breed in Siberia must fly 3700 without stopping, and individuals which will breed in Alaska must depart from South Korea or Japan and fly 5000 (Wilson *et al*., 2007).

Of the 2 species and 4,285 individuals of genus *Limosa*, 3,214 individuals (75.00%) were bar-tailed godwit. 2,216 individuals (72.66%) out of the total 3,050 individuals were observed in the early 1990s, and 998 individuals (80.81%) out of the total 1,235 individuals were observed in the mid-2000s, showing significant decrease in numbers during the 2000s. It is assessed that the number of the black-tailed godwit and the bar-tailed godwit arriving in Nakdong River estuary in the mid-2000s decreased as a result of habitat reduction and aquatic pollution caused by long periods of rain and residential area developments. It is predicted that a high percentage of the individuals which have arrived in the Nakdong River estuary use the mudflats of the Yellow Sea as their habitat.

The above result was also explained by the study on

Yubu Island of the west coast of Korea, an important water birds habitat, by Lee *et al* (2002). In the study conducted between 1999 and the 2000s, 14 individuals of the black-tailed godwit and 4,225 individuals of the bar-tailed godwit were recorded, and the 2 species made up 5.78% (4,239 individuals) of the total number of genus *Limosa*. While a total of 68 individuals of the bar-tailed godwit was observed in fall, with 53 individuals in August and 15 individuals in September, a total of 4,157 individuals was observed in spring, with 120 individuals in March, 1,037 individuals in April and 3,000 individuals in May. This result may be related to the fact that the bar-tailed godwit generally prefer the mudflats of the Yellow Sea to Nakdonggang estuary while migrating to their breeding ground (Lee *et al*., 2002).

In terms of the number of individuals observed monthly in the 5 regions, a total of 1,235 individuals were observed for the 6 years, with 821 individuals in Daemadeung, 86 individuals in Jangja · Shinja, 180 individuals in Saja · Doyodeung, 107 individuals in southern Eulsukdo and 41 individuals in Eulsukdo.

In the case of the regional number of individuals observed monthly, 201 individuals were observed in May, 66 individuals in August, 56 individuals in September, 90 individuals in October and 391 individuals in April in Daemadeung. And 27 individuals were observed in August, 48 individuals in September and 102 individuals in October in Saja · Doyodeung, and 69 individuals were observed in August and 38 individuals in October in southern Eulseukdo.

During migration to nesting ground and wintering ground in spring and fall, genus *Limosa* of family Scolopacidae tend to use Saja · Doyodeung, which is connected to southern Eulsukdo, as their habitat. Daemadeung was used especially in spring and fall, and Saja · Doyodeung were used in fall. This is predicted to be related to the habitat and food preferred by genus *Limosa.*

The black-tailed godwit and the bar-tailed godwit feed primarily on invertebrates, such as insects, mollusks, crustaceans and annelid worms, and the bar-tailed godwit are known more active feeders than the black-tailed godwit (Cramp and Simmons, 1983).

According to the report by Busan Metropolitan City (2006), macrozoobenthos were found in a relatively diverse level in western and northern Daemadeung. On the other hand, the use of southern Eulsukdo and Saja · Doyodeung as habitat in fall may be explained by the birds' selecting a region with easier access for the migration to the south. A past study has reported that a high number of the bar-tailed godwit was found in South Korea after the breeding season and before their migration to the south (Moores, 1999). They were also found in lower numbers in Japan before migrating to the south than before migrating to the north (Anon, 1998), so it is assessed that the Nakdong River estuary is a crucial location for migration to the south.

For the importance of Nakdong River estuary to the birds, this area must be preserved to prevent water pollution, habitat reduction and other detrimental effects by the systematic management such as artificial installations, maintaining a distance from the human population and restoring feeding ground.

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